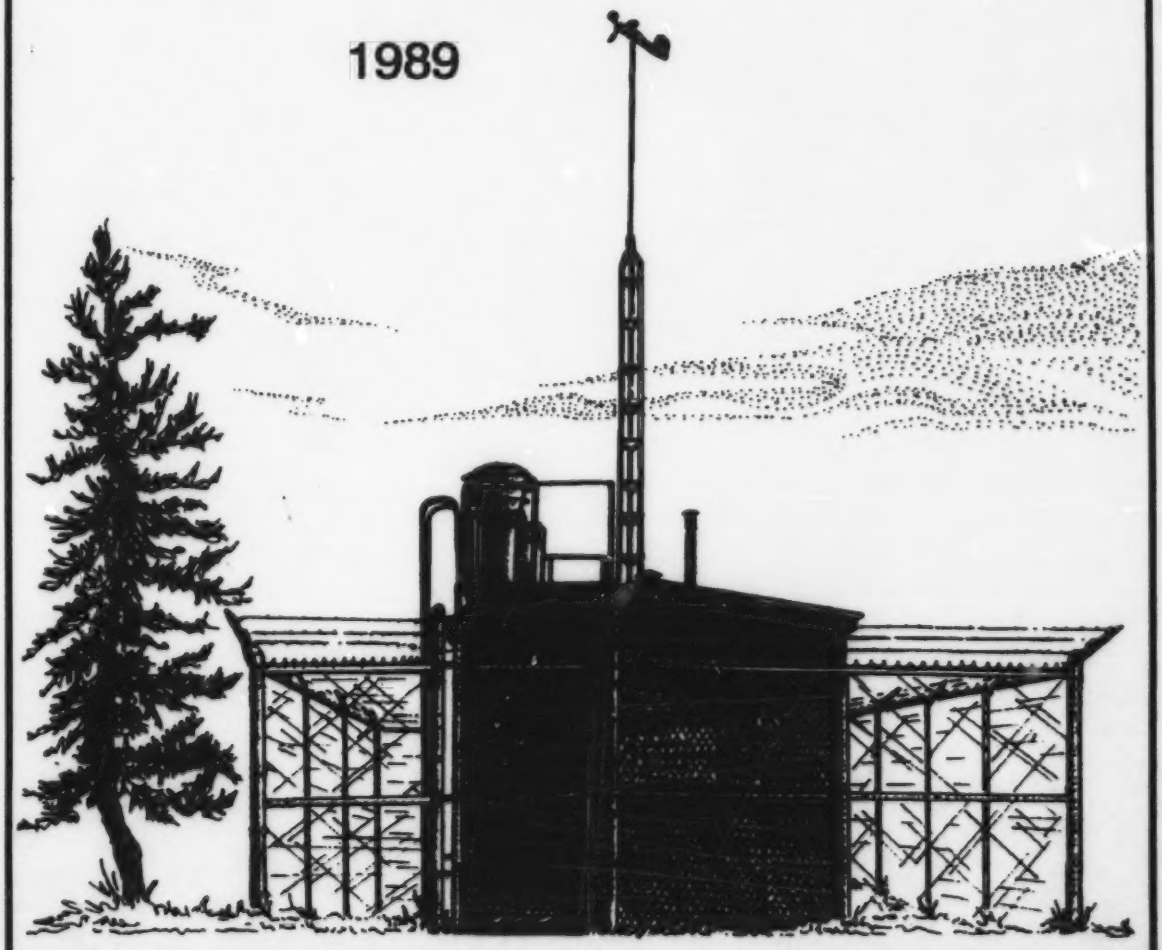
AIR QUALITY

NORTHWESTERN ONTARIO

1989



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NORTHWESTERN ONTARIO

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SUMMARY

This technical memorandum presents results of the Ministry's air quality assessment program for 1989 in northwestern Ontario. It includes data from 10 communities where long-term monitoring is conducted, plus summaries of special surveys in Thunder Bay.

ATIKOKAN

The Ministry and Ontario Hydro concluded some portions of their monitoring programs around the 200-megawatt thermal generating station near Atikokan. During 1989, there were no exceedences of air quality objectives for sulphur dioxide, nitrogen dioxide or ozone.

Near the Proboard Limited particleboard plant, average dustfall complied with the provincial objective at two of the four monitoring sites. Dustfall slightly exceeded the objective at the other two sites. Proboard was not implicated as the source of elevated dustfall readings.

BALMERTOWN

Arsenic persisted at elevated concentrations in vegetation on company property near two gold mines, but was near normal in the adjoining townsite. Arsenic levels in vegetation have generally declined during the past 3 years.

During the growing season (May to September), hourly average sulphur dioxide exceeded the acceptable limit 34 times, compared with 19 occurrences in 1988, 23 in 1987, and 28 in 1986. There was no visible vegetation injury caused by sulphur dioxide on mine property or in the townsite. The principal sulphur dioxide source is the ore concentrate roaster at the Campbell Red Lake Mine. By 1992, the roaster will be shut down; emissions of sulphur dioxide (and arsenic) from this source will cease at that time.

DRYDEN

Odour levels in central Dryden continued the excellent trend of improvement recorded in recent years. The Ontario guideline for total reduced sulphur (TRS) was not exceeded at any time in 1989.

FORT FRANCES

There was no visible off-property vegetation damage caused by air emissions from the local kraft pulp mill. For the first time since 1972, foliar sodium levels were below the contaminant guideline.

Average dustfall continued to exceed Ministry objectives off mill property, but dustfall was lower in 1989 than in recent preceding years. Improved emission controls on the mill's recovery boiler are credited for this improvement. Average suspended particulate concentrations were also acceptable.

Improved odour emission controls also resulted in fewer exceedences of the TRS guideline near the Fort Frances mill: 414 hours above the guideline in 1989, compared with 552 in 1988. Other odour controls being introduced in 1990 should further improve community air quality.

KENORA

Some exceedences of the Ontario dustfall objective were recorded at one of the four monitoring sites near a sulphite pulp mill. The mill will be upgrading pollution controls on its power boiler system, which is the main source of particulate emissions.

MARATHON

There was general compliance with dustfall objectives near a wood-chip storage area at a local kraft pulp mill.

Odour levels near the mill improved in 1989; during the year, there were 54 exceedences of the TRS guideline compared with 109 in 1988.

An air emission inventory carried out by the mill in 1989 showed some emission sources were not in compliance with Ministry regulations. This issue will be addressed through a Control Order or through mill modernization plans.

RED LAKE

Following two exceedences of the air quality objectives for lead in 1988, lead levels have been satisfactory near a mineral assay laboratory in Red Lake. Emission controls were installed in 1989.

RED ROCK

Nearly 90% of dustfall measurements complied with Ministry objectives near a kraft pulp mill in Red Rock. The few exceedences, caused by wood fines or bark char, were not severe enough to warrant special abatement action.

Air quality with respect to odours was much improved in 1989 compared with 1988. The provincial TRS guideline was exceeded only 44 times in 1989, compared with 173 exceedences in 1988.

SCHREIBER

Recent surveys have shown much reduced levels of airborne cadmium, copper and zinc near an ore concentrate transhipment area on CPR property in Schreiber. A dust control program implemented by CP Rail was responsible for this improvement.

TERRACE BAY

Air quality in Terrace Bay in 1989 improved from 1987 and 1988. About half the TRS guideline exceedences in 1989 occurred in September and October. Since then, infractions of the guideline have rarely occurred.

Data from a TRS monitor near the mill's new secondary wastewater treatment system show that the system, to date, is not a significant odour source.

THUNDER BAY

Average dustfall in Thunder Bay in 1989 was within the acceptable range at 9 of the 10 monitoring sites in the city. Particulate emissions from a local pulp mill caused dustfall at one site to slightly exceed the Ontario objective.

Suspended particulate matter met the annual provincial objective at all sites monitored. Soiling index levels were also acceptable at all times during the year.

Concentrations of carbon monoxide, nitrogen dioxide, and sulphur dioxide consistently met Ministry objectives in 1989. Ozone was above the maximum acceptable limit for 5 hours during the year. The TRS guideline near a kraft pulp mill was slightly exceeded during 2 hours. During the year, Thunder Bay's air quality index was "very good" or "good" for all but 4 hours, when it was "moderate" due to TRS.

Airborne dust levels were satisfactory in residential areas near Thunder Bay Terminals Limited. However, snow sampling revealed off-property spread of coal dust on the Lake Superior side of the facility.

INTRODUCTION

1.0 PURPOSE OF MONITORING PROGRAM

The Ontario Ministry of the Environment conducts air quality assessment programs throughout the province. Monitoring networks record outdoor concentrations of pollutants that may adversely affect human health, animal life, vegetation, and the use and enjoyment of property. These surveys document compliance with air quality objectives, and determine long-term air quality trends. The monitoring program identifies pollution sources and assesses the results of pollution control measures.

In northwestern Ontario, air quality surveys first began in 1963, to measure airborne dust in the City of Thunder Bay. In 1989, the regional monitoring network covered 11 communities, with nearly 90 monitoring devices. More than 20 different pollutants are measured, plus meteorological parameters. Ontario Hydro also has air quality networks in Thunder Bay and Atikokan.

Data from air quality and meteorological instruments are supplemented by vegetation, soil and snow sampling studies, and by predictions of pollutant levels with mathematical models.

Monitoring in the region is mostly conducted in urban areas and near industrial sources of air pollution (eg. mines, pulp and paper mills). Therefore, air quality problems described in this report are not typical of the region, where air quality is generally excellent.

Acid rain is a major environmental issue in eastern North America and in parts of Europe. Ontario, through its Acidic Precipitation in Ontario Study, is assessing the effects of acid fallout and has developed some answers to this problem. The Ministry's Northwestern Region currently participates in this program through precipitation sampling surveys at nine sites and

through lake sampling surveys. The findings of these studies are reported elsewhere.

The installation of a telemetry system in 1986 was a major new enhancement of the region's air quality monitoring program. This system greatly increases the speed with which air quality data are received. It permits the Ministry to obtain immediate readings from any continuous monitor. Beginning in early June, 1988, an Air Quality Index (AQI) has been issued eight times daily for Thunder Bay and other cities in Ontario. The AQI is based on readings for six pollutants: carbon monoxide, ozone, nitrogen dioxide, particulate matter (soiling index), sulphur dioxide, and total reduced sulphur. In September 1989, an AQI station was added in Fort Frances for publication of levels of total reduced sulphur. Other communities may be added in future.

2.0 POLLUTANTS AND THEIR MEASUREMENT

Under this heading, only those contaminants routinely monitored in northwestern Ontario are considered. Hydrocarbons are not presently measured, nor are exotic organic compounds. If the need arises, many of the more unusual pollutants can be monitored with mobile equipment from the Ministry's Air Resources Branch, Toronto.

2.1 Particulate Matter

There are many man-made and natural sources of airborne particulate matter. Typical man-made sources in northwestern Ontario are forest product industries and mining operations. Wind-blown particles from stored materials and roadways are examples of secondary sources. Particulate matter may also be emitted from forest fires, volcanoes, and dust storms. Depending on particle size and chemical makeup, particulate matter may be harmful to health and vegetation, may adversely affect visibility, and may cause local nuisance problems. In Ontario, particulate matter is measured as dustfall, total suspended particulate matter (TSP), inhalable particulate matter (IPM), and soiling index.

Dustfall is particulate matter that settles out from the air by gravity. Open-top containers (dustfall jars) are exposed for 30-day periods and the collected matter is weighed.[1] The monthly air quality objective (maximum acceptable limit) for dustfall is 7 $g/m^2/30$ d (grams per square metre during 30 days). The annual objective is 4.6 $g/m^2/30$ d. Dustfall estimates the fallout of particulate matter from local sources, including dust from construction or from vehicles. It is rarely considered to be a health-related pollutant, but may cause a significant nuisance because of soiling effects.

Suspended particulate matter comprises particles of small size which remain entrained in the air for long periods. This material may come from local or distant sources. It is measured with a high-volume sampler for a 24-hour period every sixth day.[2] The difference in the weight of a fibreglass filter before and after exposure determines the quantity of particulate matter collected. The air quality objective is 120 $\mu g/m^3$ (micrograms per cubic metre of air sampled) averaged over 24 hours, and 60 $\mu g/m^3$, annual geometric mean.

Inhalable particulate matter is particulate matter with particles smaller than 10μm (micrometres) in diameter. It is measured with a standard high-volume sampler fitted with a size-selective inlet. Samples are collected on a quartz filter exposed for a 24-hour period every sixth day. An Ontario air quality objective for inhalable particulate matter is being developed.

Soiling index is a measure of the soiling or darkening properties of very small airborne particles and is expressed as coefficient of haze (COH). It is related to the concentration of respirable particulate matter. A measured volume of air passes through a paper tape which moves through an automated sampling unit to produce a reading every hour. The reduction of light transmitted through the tape is expressed as coefficient of haze (COH) per 1,000 linear feet of air sampled. The Ontario objective is 1.0 COH, 24-hour average, and 0.5 COH, annual average.

2.2 Gaseous Pollutants

2.2.1 Carbon Monoxide (CO)

Carbon monoxide is a colourless, odourless gas. Its primary source (about 80%) is motor vehicles. A secondary source is fossil fuel combustion. As the number of vehicles in northwestern Ontario is small relative to other parts of the province, carbon monoxide is not a problem pollutant in this region. Elevated concentrations of carbon monoxide cause well-known health effects. The maximum acceptable level in Ontario is 30 ppm (parts of carbon monoxide per million parts of air), 1-hour average, and 13 ppm, 8-hour average. This pollutant is measured with a continuous analyzer[3] at one location in Thunder Bay.

2.2.2 Nitrogen Oxides (NO_x)

Nitric oxide (NO) and nitrogen dioxide (NO_2) are together termed nitrogen oxides (NO_x). Both NO and NO_2 may be emitted from natural and man-made sources. High-temperature fuel combustion, which occurs in vehicle engines and thermal power plants, is the main man-made emission source. At concentrations measured in ambient air, NO has no known adverse effects. NO may, however, oxidize to NO_2 which, in turn, may adversely affect health and visibility. NO_2 also reacts with hydrocarbons in sunlight to form ozone. It may also combine with water to form nitric acid, a component of acid rain. Nitrogen oxides are monitored with continuous analyzers.[4] The air quality objectives for NO_2 in Ontario are 0.2 ppm, 1-hour average, and 0.1 ppm, daily average.

2.2.3 Ozone (O_3)

Ozone occurs naturally and beneficially in the upper atmosphere. Near the ground, it is a product of reactions between nitrogen oxides and hydrocarbons. If present at high

concentrations, it may adversely affect health and damage vegetation. Since ozone-forming compounds are not emitted in large amounts in northwestern Ontario, elevated ozone readings, if present, would suggest long-range transport from outside the region. Ozone is measured with continuous analysers,[5] and the current air quality objective is 0.08 ppm, averaged over one hour.

2.2.4 Sulphur Dioxide (SO_2)

Sulphur dioxide is one of the world's major atmospheric pollutants and has many well-known adverse effects on human health, vegetation and property. It is also one of the main contributors to acid rain. In northwestern Ontario, the principal SO_2 sources are small compared to those in some other parts of the province. The main regional emitters of SO_2 are, in approximate descending order of importance, Ontario Hydro generating stations (Thunder Bay and Atikokan), sulphite pulp mills, gold ore roasting, and industrial boilers. Sulphur dioxide is monitored with continuous analyzers.[6] There are three air quality objectives for this pollutant: 0.25 ppm, hourly average; 0.10 ppm, 24-hour average; and 0.02 ppm, annual average.

2.2.5 Total Reduced Sulphur (TRS)

Total reduced sulphur comprises a group of sulphur-containing gases found in emissions from kraft pulp mills, which are the sole significant TRS sources in the region. At very low concentrations, TRS results in offensive odours. Higher levels may cause temporary discomfort to sensitive individuals. In Ontario, a guideline of 27 ppb (parts of TRS, expressed as hydrogen sulphide, per billion parts of air), averaged over one hour, is used as an air quality objective near kraft pulp mills. TRS is measured with continuous analysers.[7]

2.3 Miscellaneous

The occurrence and effects of some of the foregoing pollutants, plus others, may be assessed by vegetation injury and by determining contaminant levels in vegetation, soil and snow. Standard Ministry procedures,[8,9,10] are followed in collecting and analysing these types of samples. Arsenic, chloride, fluoride,[11] sulphur and heavy metals are typical pollutants examined this way. Their levels in a study area are compared with normal background values at sites unaffected by pollution. Contaminant guidelines developed by the Ministry for vegetation, soil and snow are used in this report. The guidelines are based on the upper limit of "normal" elemental concentrations across the province. Exceedence of a guideline may indicate a contamination problem. However, it is not a violation of Ministry regulations, nor does it necessarily imply health or environmental effects.

Most analyses for vegetation, soil and snow, are carried out at the Ministry's Thunder Bay laboratory. The Ministry's Toronto laboratory analyses metals, nitrate, and sulphate in suspended particulate and in inhalable particulate matter, and sulphur and halides (chloride, fluoride) in vegetation and soil. The Toronto laboratory also analyses unusual contaminants (e.g. organic compounds such as PCBs or pesticides). A private laboratory carries out dustfall and suspended particulate matter determinations.

The Ministry's Air Resources Branch produces computer printouts of all air quality and meteorological data for the region.

RESULTS

3.0 ATIKOKAN

3.1 Ontario Hydro Generating Station

In 1981, the Ministry and Ontario Hydro began an air quality

assessment program around a lignite-fired generating station under construction near Atikokan. Ontario Hydro operates the air quality monitoring network and the Ministry collects precipitation, vegetation, soil, and snow samples at several sites (Figure 1).

By late 1985, when the 200-megawatt plant went into service, at least three years of background data had been collected. A summary report for the pre-operational terrestrial and atmospheric deposition studies was issued in 1986.[12]

The Ministry and Ontario Hydro continued their monitoring programs during 1986, 1987 and 1988, the first three operational years for the power plant. Ontario Hydro's environmental quality compliance reports show that no exceedences of Ontario's air quality objectives for sulphur dioxide, ozone, or nitrogen dioxide were recorded during this period, or in 1989. Reports on atmospheric deposition and terrestrial data for the same period revealed no significant changes from the pre-operational period.[13,14] The terrestrial studies concluded in 1988; re-sampling is scheduled for 1992. In 1990, deposition monitoring will be discontinued at Lac La Croix. Quetico Centre (Eva Lake) will continue as a cummulative sampling site, but daily measurements at this location will terminate. Monitoring at Fernberg Road (northern Minnesota) will continue unaltered.

In 1989, at the Ministry's long-term monitoring site in the Town of Atikokan, all but one of the 51 TSP samples met the 24-hour air quality objective of 120 $\mu g/m^3$. The annual geometric mean of 29 $\mu g/m^3$ also complied with the limit of 60 $\mu g/m^3$, and was similar to values for preceding years.

3.2 Proboard Limited

A small 4-station network (Figure 2) was established in October, 1987, to monitor dustfall near Proboard Limited (formerly

Pluswood Manufacturing Limited). This company produces particleboard. In 1989, monthly dustfall exceeded the Ministry objective in 10 of 48 samples. Annual average dustfall was acceptable at two sites and slightly above the objective of 7.0 $g/m^2/30$ days at the other two sites. Elevated readings were associated with road dust or biological matter. The 1989 data did not indicate a fallout problem caused by emissions from Proboard. Dustfall measurements were terminated in December, 1989.

4.0 BALMERTOWN

The Ministry has conducted air quality surveys near two gold mines in Balmertown since 1971. For many years, Campbell Red Lake Mines Limited, and the Dickenson Mines Limited, Arthur W. White Mine (formerly Dickenson-Sullivan Joint Venture), emitted significant amounts of airborne arsenic trioxide and sulphur dioxide from ore roaster stacks. In the mid-1970's, both mines reduced arsenic emissions by more than 95%. In early 1980, Dickenson shut down its roaster.

4.1 Arsenic

In 1989, arsenic concentrations in leaves of trembling aspen trees at 17 sites near the mines (Figure 3) remained elevated on mine properties but were near normal levels in the townsite. The elevated arsenic near the mines is ascribed to localized fugitive emissions from arsenic-containing wastes or from concentrates. Stack emissions may also contribute to arsenic fallout. Table 1 compares arsenic readings for the past 5 years at selected sites on and off mine properties. Average arsenic declined during the past 3 years. Table 2 presents data for the same period from planted roadside trees in the townsite. Both tables show that current arsenic levels in tree vegetation in the townsite are above normal background concentrations. Arsenic at sites 13 and 14 on Dickenson's property (Table 1) dropped sharply from 1988 to 1989.

Because residential gardens regularly sampled in Balmertown were no longer in use, garden vegetables were not sampled in 1989. In recent years, arsenic levels in vegetables have been acceptable. Because arsenic in garden soil remains high, Balmertown residents have been advised to thoroughly wash vegetables from their gardens.

4.2 Mercury

Because mercury is still used in ore processing at Dickenson, and was used at Campbell until 1982, the Ministry regularly examines mercury levels in the local environment. Mercury met the Ministry's contaminant guideline (0.1 $\mu g/g$) in trembling aspen leaves at all sites on and off mine properties in 1989. As noted earlier, vegetables were not sampled in 1989, but mercury in such samples have consistently met the recommended international guideline for mercury (0.5 $\mu g/g$, dry weight) in former years. In 1990, the use of mercury for ore processing will be terminated at Dickenson's mine.

4.3 Sulphur Dioxide

Sulphur dioxide sometimes exceeds desirable levels in Balmertown. In 1989, the Ministry's Balmertown monitor recorded 86 hourly SO_2 readings and three, 24-hour averages which exceeded acceptable levels. The maximum hourly average was 0.56 ppm, about double the Ontario objective. The annual average (0.009 ppm) was satisfactory. In 1989, there was no visible sulphur dioxide injury to vegetation on mine property or in the townsite.

During the growing season (May to September), SO_2 was above the acceptable hourly limit 34 times, compared with 19 occasions in 1988, 23 in 1987, and 28 in 1986. Table 3 summarizes the data for the past 5 years. In the 1989 growing season, 26 of the 34 exceedences of the hourly SO_2 objective occurred in May or late September, when the likelihood of vegetation damage would be minimal. During the growing season, Campbell Red Lake shuts down

its ore roaster when the wind carries roaster-stack emissions over the townsite. Generally, this program has succeeded in minimizing vegetation damage off mine property. Recently, the company decided to change its ore processing operation to eliminate roasting. This change, to be implemented by 1992, will eliminate airborne emissions of SO_2 as well as arsenic.

5.0 DRYDEN

For several years, the Ministry has monitored air quality near a bleached kraft pulp mill and former chlor-alkali plant in Dryden. Abatement action, process changes, and mill modernization have resolved most of the air quality concerns of the 1970's and early 1980's. Currently, the Ministry monitors odour levels in the town centre.

5.1 Odour Levels

Offensive odours caused by reduced sulphur compounds are monitored with a continuous TRS analyzer in central Dryden (station 61027, Figure 4). As Table 4 shows, odour levels in 1989 were satisfactory throughout the year. There were no exceedences of the provincial guideline for TRS.

6.0 FORT FRANCES

During its first few years of operation, emissions from a bleached kraft pulp mill in Fort Frances resulted in particulate fallout and odour problems in a nearby residential area. In the late 1970's, some emission reductions were achieved. In 1980, a Control Order was issued for further pollution controls. The mill also created a "buffer zone" through purchase of adjacent residential land.

Air quality studies in Fort Frances have been conducted regularly since 1972 near the Canadian mill, and periodically since 1974 around a similar plant owned by the parent corporation on the U.S. side of the border nearby (Figure 5).

6.1 Vegetation Effects

In 1989, there was no visible air pollution injury to vegetation inside or outside the buffer zone around the Fort Frances mill. The condition of trees which had suffered damage in past years was mostly unchanged from 1988. Chloride and sodium in tree foliage were very low in 1989 samples (Table 5). In fact, 1989 was the first year since sampling began in 1972 that foliar sodium levels were consistently below the Ministry's contaminant guideline. Foliar chloride levels have declined steadily during the 1980s.

There was no visible off-property damage to vegetation around the pulp mill's secondary effluent treatment system on Eighth Street (Figure 6).

6.2 Particulate Matter

Dustfall results for 1989 are summarized in Table 6. The annual air quality objective for dustfall was met at the three most distant monitoring sites from the mill (stations 62032, 62034 and 62037). On-property dustfall averaged more than twice the objective. Dustfall in the nearby residential area (excluding the two most distant sites) averaged 28% above the objective. Wood fibres accounted for about 25 to 75% of total dustfall when high dustfall readings occurred at these sites (stations 62034, 62035, 62036 and 62050). Road dust, fly ash, and insect parts were also sometimes present in significant amounts in dustfall, mainly during the summer. A comparison of average dustfall during recent years (Table 7) shows a trend of moderate decline, which is encouraging.

In 1989, total suspended particulate matter (TSP) was typical of the value recorded in recent years. The annual average TSP at the monitoring site near the mill (station 62035) was 56 $\mu g/m^3$, which met the provincial objective. Nine of the 57 daily readings at this site exceeded the 24-hour objective. Highest levels occurred during calm conditions or with south to southwest wind, when the monitor was downwind of the mill. The annual average TSP at the Fort Frances cemetery (station 62032) was 29 $\mu g/m^3$, which is normal for this location and well within the Ontario objective. There were no exceedences of the daily objective at this site.

6.3 Odour Levels

The number of exceedences of the TRS guideline in Fort Frances decreased from 1988 to 1989 (Table 8). The reduction in average TRS near the Fort Frances mill may have resulted from reduced emissions from the mill; in mid-year, a new scrubber was installed at the mill's tall oil plant. At the cemetery monitoring site (station 62032), average TRS levels were similar to those recorded in recent preceding years.

Condensate stripping , to be in place at the Fort Frances mill by the spring of 1990, should further reduce community odour levels. Odour controls are also being upgraded at the International Falls pulp mill.

Two new TRS monitoring sites were established in November, 1989. One site is located at La Verendrye Hospital (station 62051) and one (station 62047) is on Eighth Street near the secondary treatment system (lagoon). These monitors will provide better coverage of the town and will help identify more accurately the sources contributing to community odours. Because the new stations operated for only a few weeks in 1989, data from these sites are not included in this report. Data from the monitoring station near the Civic Centre (station 62030) was published daily as an Air Quality Index (AQI) starting November 15, 1989. During the last 6 weeks of the year, the AQI was moderate for 116 hours, and poor during 35 hours. At other times, the Index was very good or good.

7.0 KENORA

For many years, the Ministry has monitored air quality near a sulphite pulp mill in Kenora. The current monitoring program includes dustfall measurements at four locations (Figure 7).

7.1 Particulate Matter

As Table 9 shows, average dustfall in Kenora in 1989 was somewhat lower than levels found in recent preceding years. Dustfall most frequently exceeded the monthly objective at station 61007, just north of the mill. At this site, road dust was the main component of dustfall when elevated readings occurred. Wood or bark char and woodfines were minor constituents. Installation of a new $5 million precipitator should improve control of particulate emissions from the pulp mill's power boilers.

8.0 MARATHON

The Ministry currently maintains one air quality monitoring station in Marathon (Figure 8). A continuous analyzer at this station monitors odour levels near the kraft pulp mill operated by James River-Marathon, Ltd. The company also has dustfall jars at five sites to measure fallout of particulate matter near a storage area for wood chips.

8.1 Particulate Matter

The fallout of wood fines from wood-chip piles near the pulp mill ("wood storage area", Figure 8) has been studied by the company and by the Ministry.[15] Dustfall measurements for 1989 by the company indicate general compliance with dustfall objectives at sites off company property. A few elevated readings occurred during the summer. Steps have been taken to reduce dust emissions from the chip piles.

8.2 Odour Levels

Average annual TRS (Table 10) and the number of guideline exceedences decreased from 1988 to 1989. To alert the mill when community odour levels exceed the desirable limit, the company telemeters TRS readings from the Ministry's monitor to the mill. Recently, James River submitted an emission inventory report which showed that emissions from the mill did not comply with Ministry regulations. The Ministry plans to issue a Control Order requiring compliance. Alternatively, concerns about air emissions may be addressed through mill modernization and expansion plans.

9.0 RED LAKE

In response to concerns about lead emissions, the Ministry began a monitoring program in early 1988 near Accurassay Laboratories Limited in Red Lake. Accurassay performs fire assays of ore samples in support of gold mining and exploration work in the area. During sample analysis, about 0.4 grams of lead per sample are lost and assumed to be discharged to atmosphere.

9.1 Lead Levels

A snow sampling survey conducted in early March, 1988, showed that lead concentrations in snow off Accurassay property slightly exceeded the Ministry's contaminant guideline.[16]

Air quality data have been collected with a high-volume sampler located on a residential property about 70 metres east of Accurassay. From February 9, 1988 to December 31, 1989, 8 of 96 samples had quantities of total suspended particulate matter exceeding the acceptable limit of 120 $\mu g/m^3$.

Two samples had lead levels above the maximum acceptable concentration of 5 $\mu g/m^3$. All the high suspended particulate and lead occurred before August, 1989, when lead emission controls were installed.

Air quality monitoring will continue near Accurassay to ensure compliance with Ministry regulations. As well, another snow sampling survey will be conducted in early 1991.

10.0 RED ROCK

The Ministry operates a small air quality monitoring network in the Town of Red Rock to measure dustfall and odour levels near a kraft pulp mill. The network comprises four dustfall jars at stations 63080 to 63083, and a continuous TRS analyser at station 63084 (Figure 9).

10.1 Particulate Matter

Table 11 summarizes dustfall in Red Rock for the past 5 years. In 1989, dustfall at three of the four monitoring sites off mill property met the annual air quality objective; at one site, the annual objective was slightly above the desirable limit. Only 5 of the 48 monthly dustfall values were above the objective of 7 $g/m^2/30$ days. Wood or bark char, or woodfines, were significant contributors to local dustfall.

10.2 Odour Levels

There were only 44 exceedences of the TRS guideline in 1989, sharply down from 173 in 1988 (Table 12). Since 1982, when a new recovery furnace was installed at the pulp mill, community odour levels have fluctuated widely. In 1989, all but 11 of the 44 TRS guideline exceedences occurred in September and October. Resolution of some operating problems may result in still further decline in odour emissions in 1990.

11.0 SCHREIBER

Some residents of Schreiber have expressed concerns about dust emissions from a transhipment facility on CP Rail property. The facility receives ore concentrate from a base metal mine 20 km northwest of Schreiber. The ore concentrate was handled at a temporary site from January to August, 1988, and thereafter at a permanent location.

11.1 Particulate Matter

The first Ministry studies showed that fallout of dust from the transhipment area resulted in significantly elevated copper and zinc in moss samples exposed off company property. Cadmium and iron were slightly above Ministry guidelines.[17,18] The latest study [19] revealed that airborne levels of cadmium, copper and zinc were acceptable during the spring and summer of 1989. Moss exposure tests showed a sharp decline in metal levels from the summer of 1988 to the summer of 1989. This improvement was attributed to a control program implemented by CP Rail in early 1989.

12.0 TERRACE BAY

The Ministry's monitoring program in Terrace Bay is directed toward measurement of odour levels in the townsite and near a new secondary treatment system (lagoon) beside the Kimberly-Clark of Canada Limited kraft pulp mill (Figure 10).

12.1 Odour Levels

In the townsite, air quality improved from 1988 to 1989. About half the TRS guideline exceedences in 1989 occurred in September and October. Since then, control of odour emissions has improved, and TRS levels have declined.

A large secondary treatment system (lagoon) for effluent from the pulp mill was brought into service in early September, 1989. In response to concerns about possible odours from the lagoon, the Ministry installed a TRS monitor at station 63093 near the lagoon (Figure 10). In 1989, there were 373 exceedences of the TRS guideline at this site, but more than 200 of these occurred before the lagoon began operating. Analysis of wind data from station 63090 in the townsite has shown that high TRS readings near the lagoon were, in fact, caused by emissions from the mill. Experience to date is that the lagoon is not a major odour source. The real test, however, will come during warm summer months.

13.0 THUNDER BAY

The Ministry maintains a 10-station air quality monitoring network in Thunder Bay. The locations of these sites, plus those operated by Ontario Hydro, are shown in Figure 11. Thunder Bay's first "full" air monitoring station (63200) was placed in service on South James Street in late 1986. At this station, sulphur dioxide, ozone, carbon monoxide, nitrogen oxides, particulate matter (soiling index) and total reduced sulphur are continuously recorded. Three of the Ministry's Thunder Bay monitoring stations (63005, 63022 and 63200) are part of Environment Canada's National Air Pollution Surveillance network. Ontario Hydro operates five sulphur dioxide monitors in Thunder Bay. Hydro also has dustfall jars on and near its Mission Island property to measure dust from flyash disposal and coal storage areas around its power plant. The following discussion reviews air quality data from the Thunder Bay area.

13.1 Particulate Matter

13.1.1 Dustfall

Dust emitted from grain elevators was formerly a nuisance to Thunder Bay residents. Dustfall measurements near the elevators

began in 1970, and the monitoring network has been revised periodically since then. The 1989 data for the 10 sites now in service are summarized in Table 14. During the year, average dustfall was below the maximum acceptable limit at 9 of 10 sites.

At Totem Trailer Court (site 63047), near Canadian Pacific Forest Products, average dustfall slightly exceeded the maximum desirable level. Bark or wood char and wood fines were the main contributors to elevated monthly readings at this site. Average dustfall in Thunder Bay has met the Ministry objective since the late 1970's. Because dustfall has been so low for many years, measurement at eight sites was suspended in December, 1989. Dustfall will continue to be monitored at the two sites (stations 63046 and 63047) nearest Canadian Pacific Forest Products Limited.

13.1.2 Suspended Particulate Matter and Soiling Index

Total suspended particulate matter was generally very satisfactory throughout Thunder Bay in 1989 (Table 15). About 97 percent of the total samples from all six monitoring sites were below the 24-hour maximum acceptable limit of 120 $\mu g/m^3$. The annual objective was met at all locations.

Samples from the two city-centre stations (stations 63005 and 63022) had acceptable concentrations of heavy metals, including lead. Levels of sulphate and nitrate, which are influenced by long-range transport, varied considerably.

At station 63200, soiling index met the daily and annual air quality objectives.

13.1.2 Inhalable Particulate Matter

Sampling for inhalable particulate matter (IPM) began at station 63200 (Walsh and James Street) in July, 1989. For the 31

samples collected during the last half of the year, IPM ranged from 8 to 63 $\mu g/m^3$, with an arithmetic mean of 25 $\mu g/m^3$. At present, Ontario does not have an objective for IPM. In the United States, standards range from 50 to 150 $\mu g/m^3$ for single samples, and from 30 to 50 $\mu g/m^3$ for annual averages.

13.2 Gaseous Pollutants

13.2.1 Carbon Monoxide, Nitrogen Dioxide and Ozone

Throughout the year, carbon monoxide was well below the maximum acceptable limit for 1-hour and 8-hour averages at station 63200. Nitrogen dioxide met the 1-hour and 24-hour objectives. Ozone exceeded the provincial 1-hour objective of 0.08 ppm during 5 hours in Thunder Bay. The maximum hourly average was 0.088 ppm. At Hawkeye Lake, 40 km north-northwest of Thunder Bay, ozone levels were above the acceptable limit during 9 hours in July, 2 hours in August, and 5 hours in October. The maximum hourly average was 0.090 ppm at Hawkeye Lake. Ozone, a long-range transport pollutant, is not currently considered a problem in northwestern Ontario. Summary figures for carbon monoxide, nitrogen dioxide and ozone are in Table 16.

13.2.2 Sulphur Dioxide

The principal industrial sources of sulphur dioxide in Thunder Bay are a 310-megawatt lignite-fired generating station and four pulp and paper mills. Collectively, these sources are relatively small; total SO_2 emissions in Thunder Bay are less than 100 metric tons per day. The network of seven SO_2 monitors (five belonging to Ontario Hydro and two owned by the Ministry) showed full compliance for all SO_2 air quality objectives in 1988 (Table 17).

13.2.3 Total Reduced Sulphur

At the Ministry's Montreal Street monitoring site (station 63046), there were two minor exceedences of the TRS guideline in 1989 (Table 18).

13.3 Air Quality Index

An hourly Air Quality Index was calculated for six pollutants monitored continuously at station 63200 (Walsh and James Street), Thunder Bay. During 1989, the Index was very good or good for all but 4 hours in October. During those hours, the Index was moderate, due to elevated concentrations of total reduced sulphur.

13.4 Special Studies

13.4.1 Thunder Bay Terminals Limited

A report on 1989 monitoring near Thunder Bay Terminals Limited[20] showed that provincial air quality objectives were met. Western coal and potash are the main products handled. There has been no increase in dust levels at off-property monitoring sites since shipments began in 1978. Snow sampling in early 1990, however, showed that visible amounts of windblown coal particles occurred on the ice-covered harbour east-southeast of the terminal. The environmental impact of this fallout is unknown, but is probably minimal.

REPORTS ISSUED IN 1989

The following list includes "green cover" reports and Technical Memoranda released during 1989. For each document, a brief summary is included. Items already in the References list, which follows, are excluded.

"Green Cover" Reports

1. Air quality, northwestern Ontario, 1987.

Results of the Ministry's air quality assessment program for 1987 in northwestern Ontario are presented.

2. Snow sampling survey in the vicinity of Kimberly-Clark of Canada Ltd. and Weldwood of Canada Ltd., Longlac, February, 1988.

Snow contaminant guidelines were slightly exceeded off company property, but dustfall objectives were met.

3. Dustfall and snow sampling survey in the vicinity of James River-Marathon, Ltd., Marathon, 1988.

Woodchip storage piles near a pulp mill were found to be a minor source of nuisance fallout in a residential area.

4. Vegetation and snow sampling surveys near Hemlo gold mines, 1988.

Metals in some samples from the Hemlo gold field near Marathon, Ontario were above normal. However, concentrations were judged to be not high enough to threaten human health or the environment.

5. Moss bag exposure survey in the vicinity of the CPR concentrate transhipment facility, Schreiber, 1987-88.

Levels of copper and zinc were much above normal near a concentrate storage area on CP Rail property. A dust control program was inititated.

6. Snow sampling survey in the vicinity of Boise Cascade Canada Ltd., Kenora, February, 1988.

Snow chemistry was near normal and dustfall objectives were met near a sulphite pulp mill.

7. Snow sampling survey in the vicinity of Minnova Inc., Schreiber, 1988.

Cadmium, copper, iron and zinc were elevated on company property. There was only one guideline exceedence (for zinc) off property.

Technical Memoranda

1. Snow sampling survey in the vicinity of Albright and Wilson Americas, Thunder Bay, February, 1989.

Emissions of chloride, chromium and sodium from a sodium chlorate plant were minor and were not expected to have an environmental impact.

2. Air quality assessment, Thunder Bay Terminals Limited, 1988.

Air quality near a bulk transhipment facility in Thunder Bay showed continued compliance in 1988 with provincial air quality objectives.

3. Air quality study, Geraldton tailings.

Levels of arsenic and heavy metals were normal in tree foliage and in moss samples exposed near gold mine tailings at Geraldton, Ontario.

4. Airborne mercury near Dickenson Mines refinery.

Mercury concentrations were above normal in moss samples exposed on the property of Dickenson's gold mine at Balmertown, Ontario. Off-property mercury levels were normal.

5. Airborne arsenic and lead in moss exposed near Dickenson Mines Limited, Balmertown, Ontario.

Arsenic was well above normal on company property and moderately above normal off-property. Lead was slightly above normal on property and normal off-property. A one-year monitoring study was initiated.

REFERENCES

1. Ontario Ministry of the Environment. 1984. Method for the sampling and determination of atmospheric dustfall. Report AMP-142. Air Resources Branch.

2. Ontario Ministry of the Environment. 1979. Method of high volume sampling and determination of total suspended particulate matter in ambient air. Report AMP-101. Air Resources Branch.

3. Ontario Ministry of the Environment. 1981. Method for the sampling and determination of carbon monoxide in ambient air by non-dispersive infrared spectrometry. Report AMP-123. Air Resources Branch.

4. Ontario Ministry of the Environment. 1981. Method for continuous sampling and determination of nitrogen dioxide and nitric oxide in ambient air by chemiluminescence. Report AMP-121. Air Resources Branch.

5. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of ozone in ambient air by chemiluminescence. Report AMP-120. Air Resources Branch.

6. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of sulphur dioxide in ambient air by fluorescence. Report AMP-118. Air Resources Branch.

7. Ontario Ministry of the Environment. 1981. Method for the continuous sampling and determination of total reduced sulphur in ambient air by fluorescence. Report AMP-130. Air Resources Branch.

8. Ontario Ministry of the Environment. 1983. Field investigation manual. Phytotoxicology Section, Air Resources Branch.

9. Ontario Ministry of the Environment. 1989. A guide to the collection and submission of samples for laboratory analysis, 6th edition. Laboratory Services Branch.

10. Ontario Ministry of the Environment. 1981. Outlines of analytical methods. Laboratory Services Branch.

11. Ontario Ministry of the Environment. 1979. Method for sampling and determination of fluoride in vegetation. Report AMP-111. Air Resources Branch.

12. Racette, D. J. and H. D. Griffin. 1986. Pre-operational terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1981 to 1985. Ontario Ministry of the Environment.

13. Racette, D. J. and H. D. Griffin. 1989. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1986. Ontario Ministry of the Environment.

14. Racette, D. J. and H. D. Griffin. 1990. Terrestrial and atmospheric deposition studies in the vicinity of the Ontario Hydro thermal generating station, Atikokan, 1987-89. Ontario Ministry of the Environment (in preparation).

15. Racette, D. J. and H. D. Griffin. 1987. Dustfall and snow sampling in the vicinity of James River-Marathon Limited, Marathon, 1985-86. Ontario Minstry of the Environment.

16. Racette, D. J. and H. D. Griffin. 1989. Snow sampling survey in the vicinity of two mineral assay laboratories in the Red Lake area, 1988. Ontario Ministry of the Environment.

17. Racette, D. J. and H. D. Griffin. 1989. Moss bag exposure survey in the vicinity of the CPR concentrate transhipment facility, Schreiber, 1987-88. Ontario Ministry of the Environment.

18. Racette, D. J. and H. D. Griffin. 1989. Snow sampling survey near the CP Rail ore concentrate transhipment facility, Schreiber, 1989. Ontario Ministry of the Environment.

19. Racette, D. J. and H. D. Griffin. 1989. Air quality studies near an ore concentrate transhipment site, Schreiber, 1989. Ontario Ministry of the Environment.

20. Griffin, H. D. 1990. Air quality assessment, Thunder Bay Terminals Limited, Thunder Bay, 1989. Ontario Ministry of the Environment (in preparation).

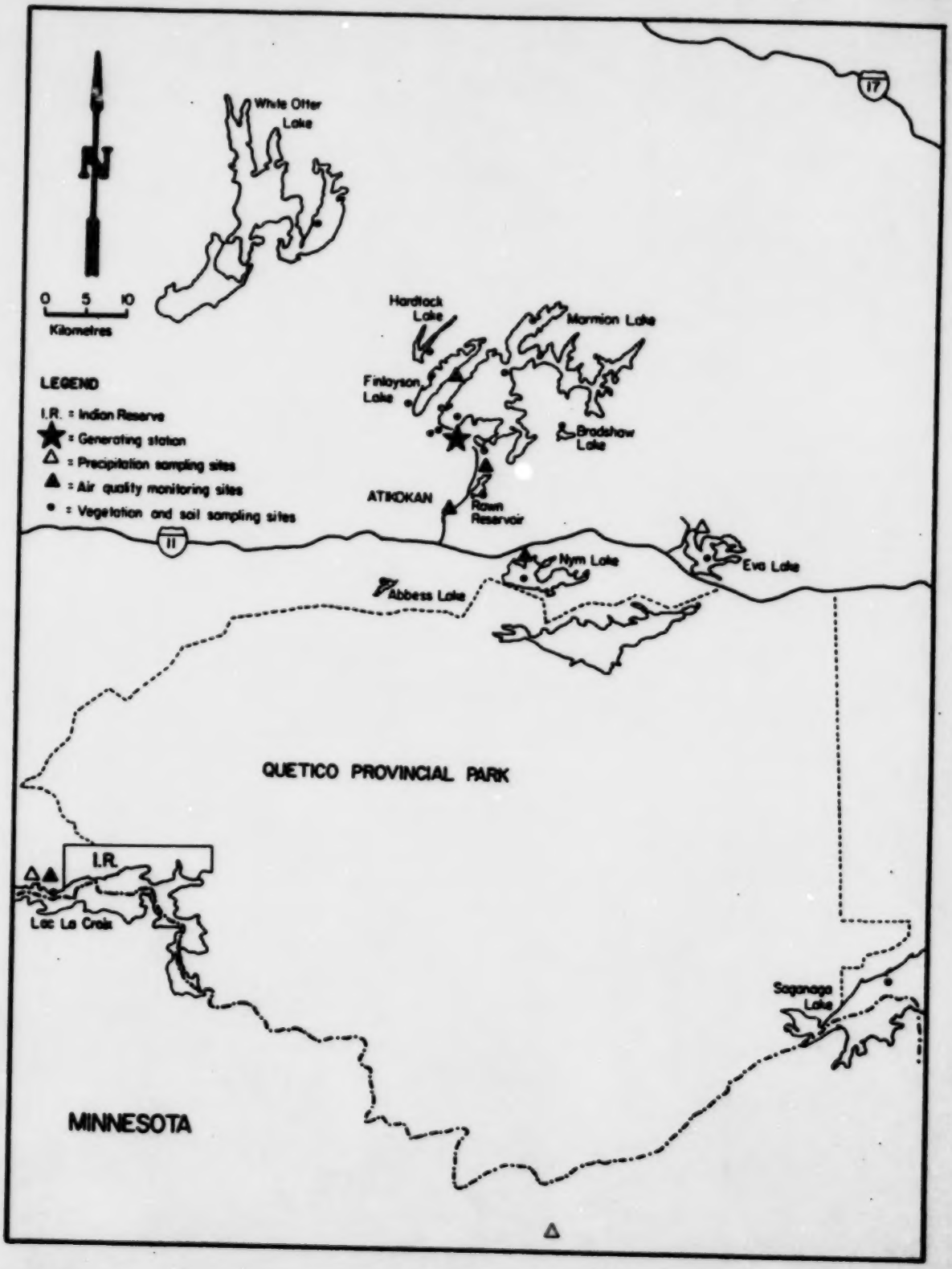

Figure 1. Air quality assessment sites, Ontario Hydro generating station, Atikokan.

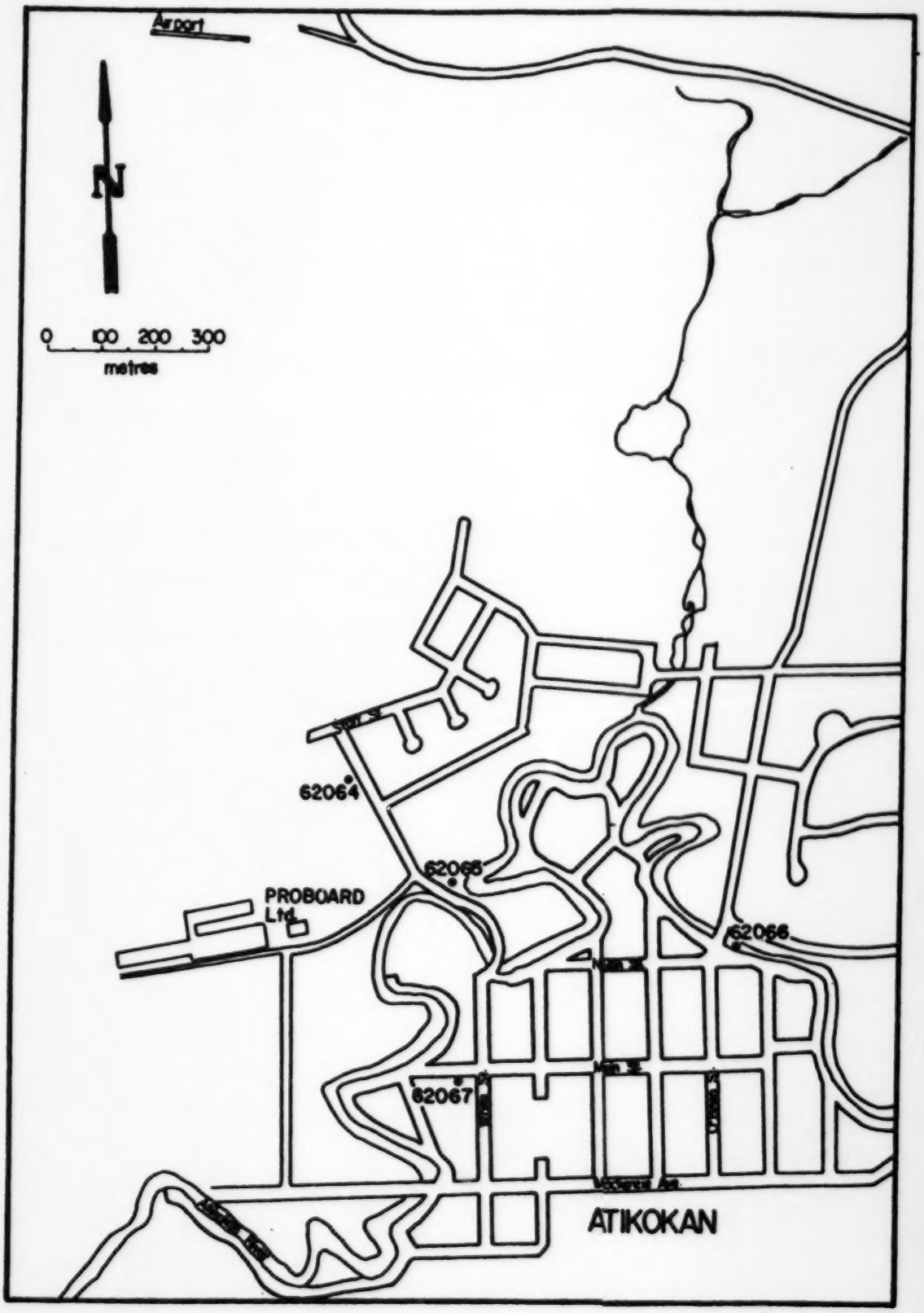

Figure 2. Air quality monitoring sites near Proboard Ltd., Atikokan.

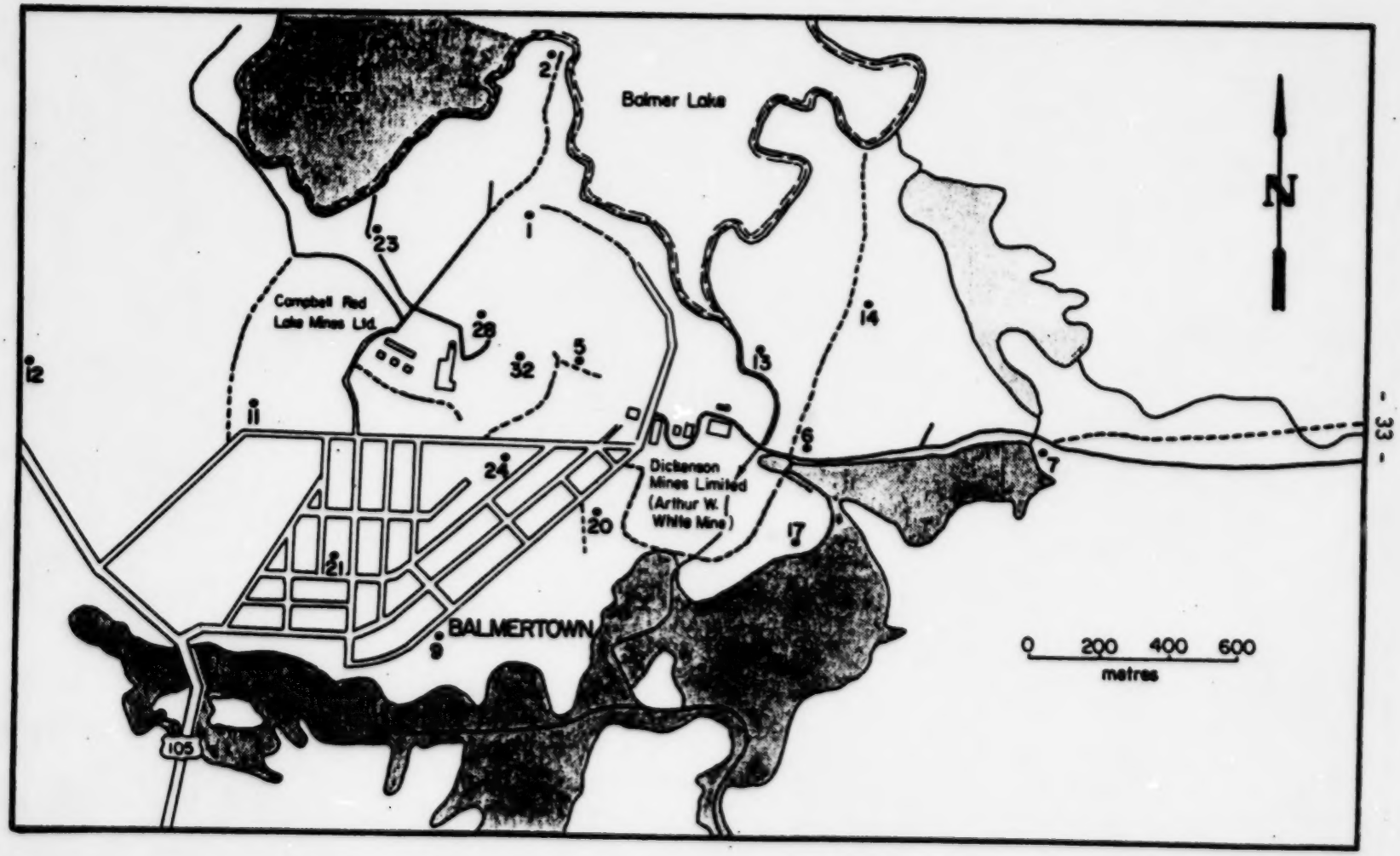

Figure 3. Trembling aspen sampling sites, Balmertown.

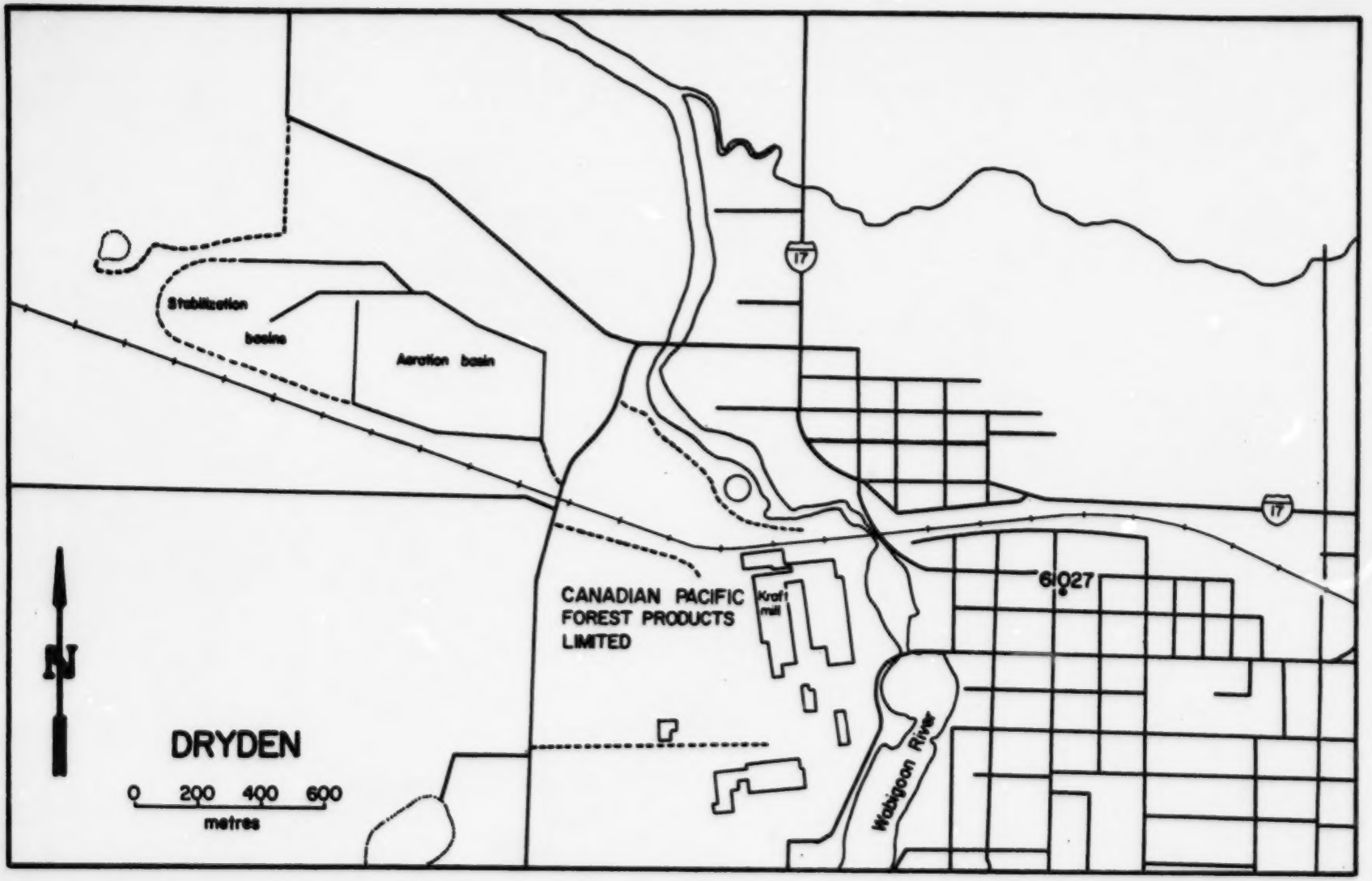

Figure 4. Air quality monitoring site, Dryden.

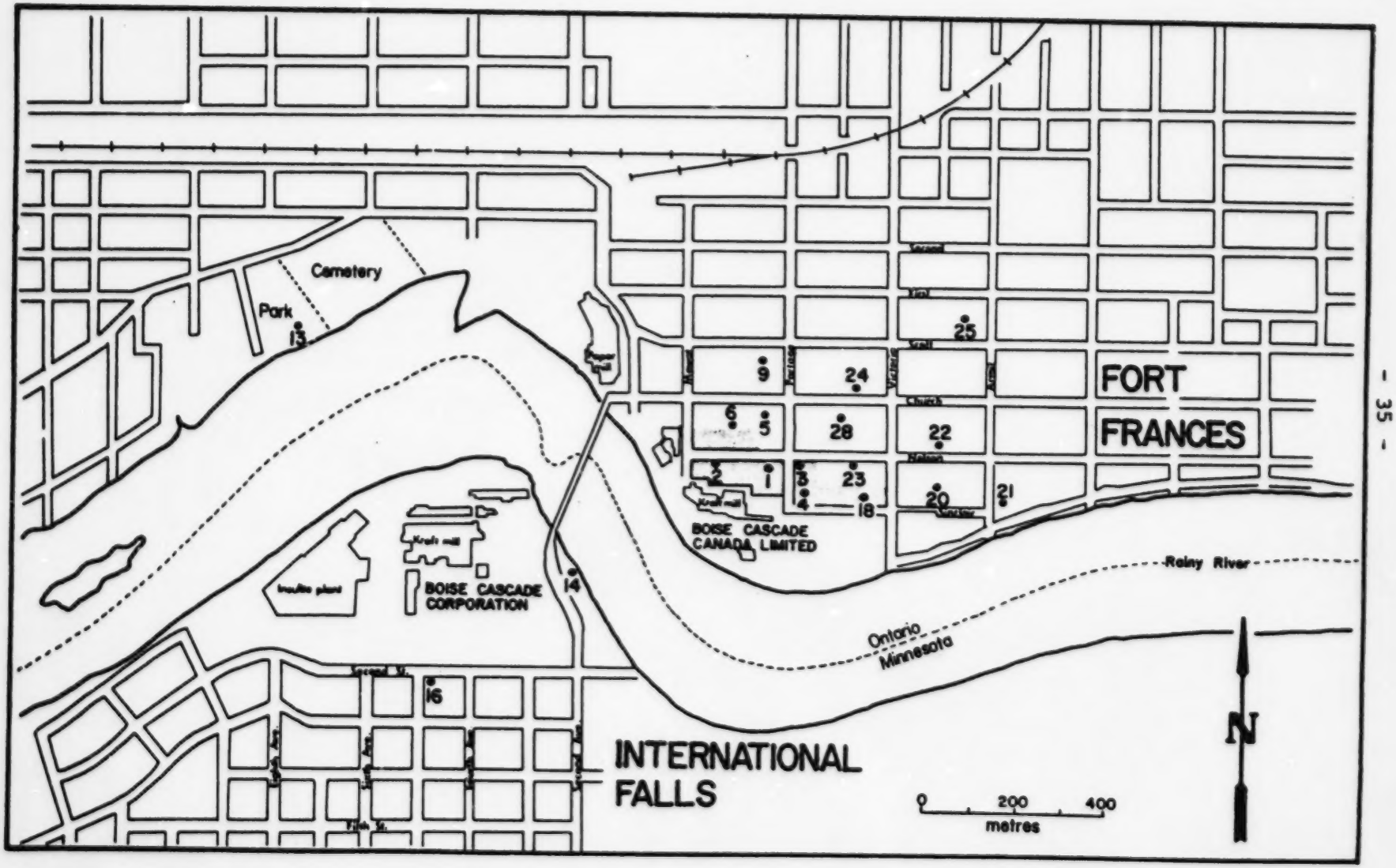

Figure 5. Manitoba maple sampling sites, Fort Frances.

Buffer zone

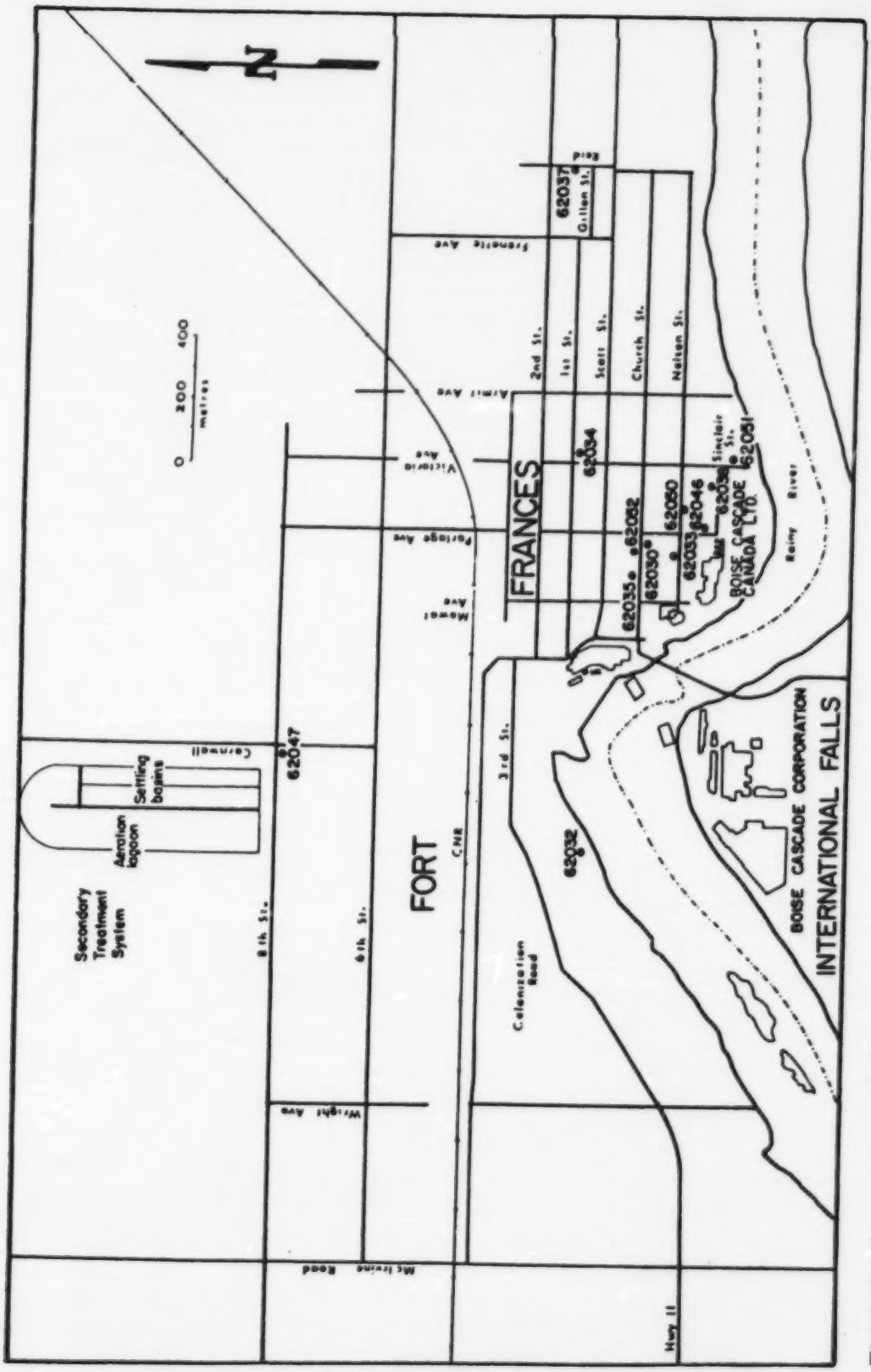

Figure 6. Air quality monitoring sites, Fort Frances.

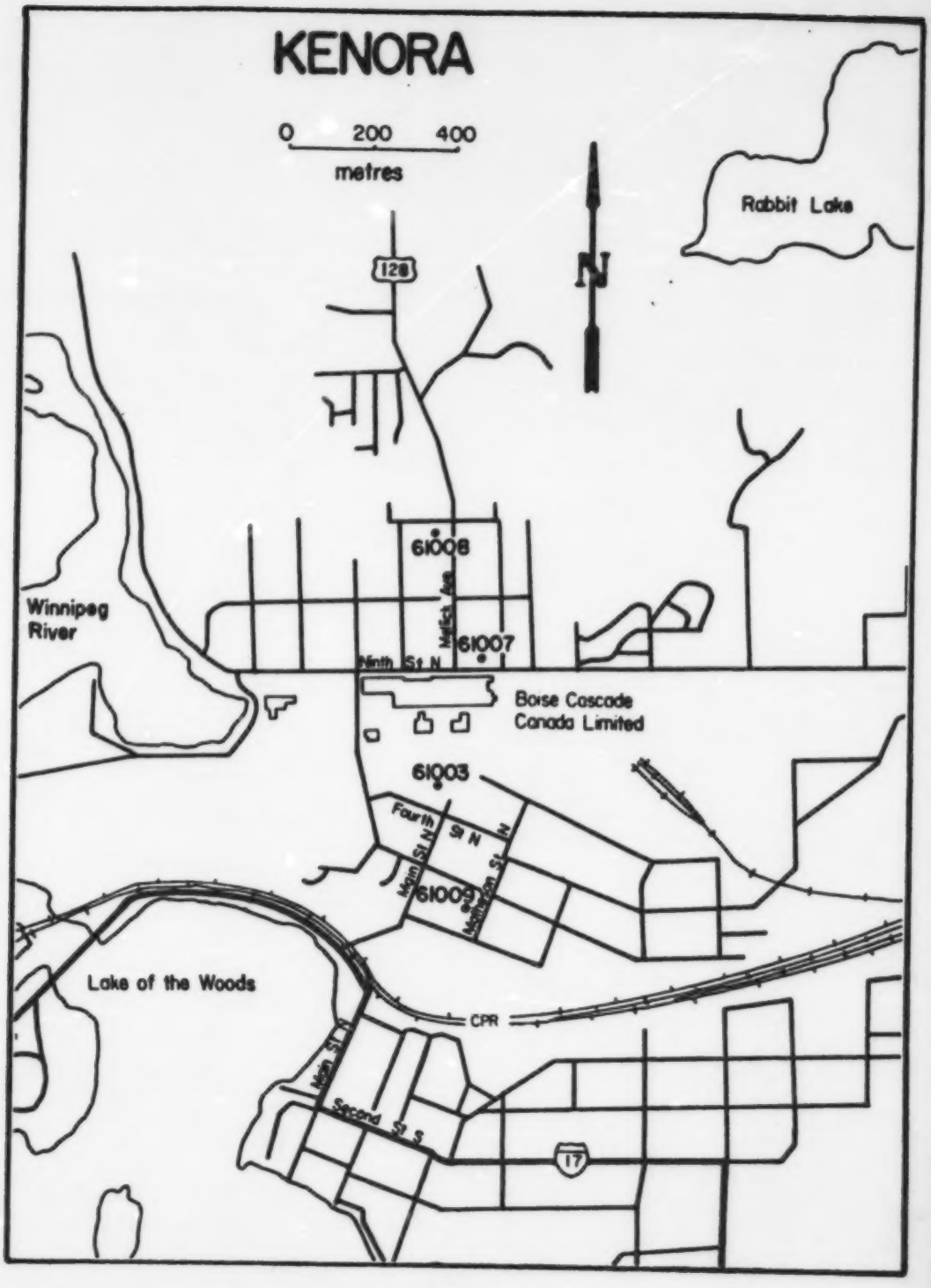

Figure 7. Air quality monitoring sites, Kenora.

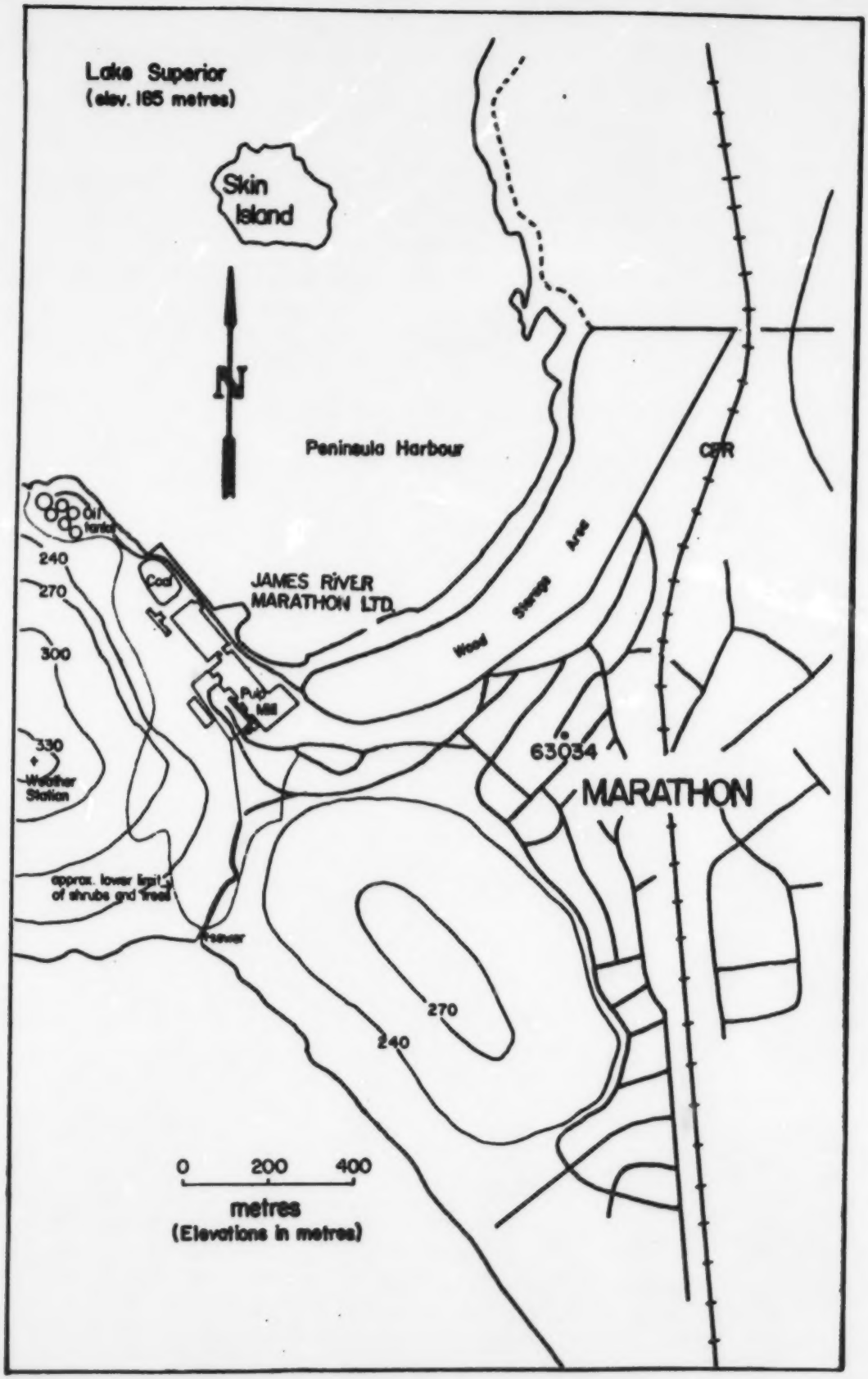

Figure 8. Air quality monitoring site, Marathon.

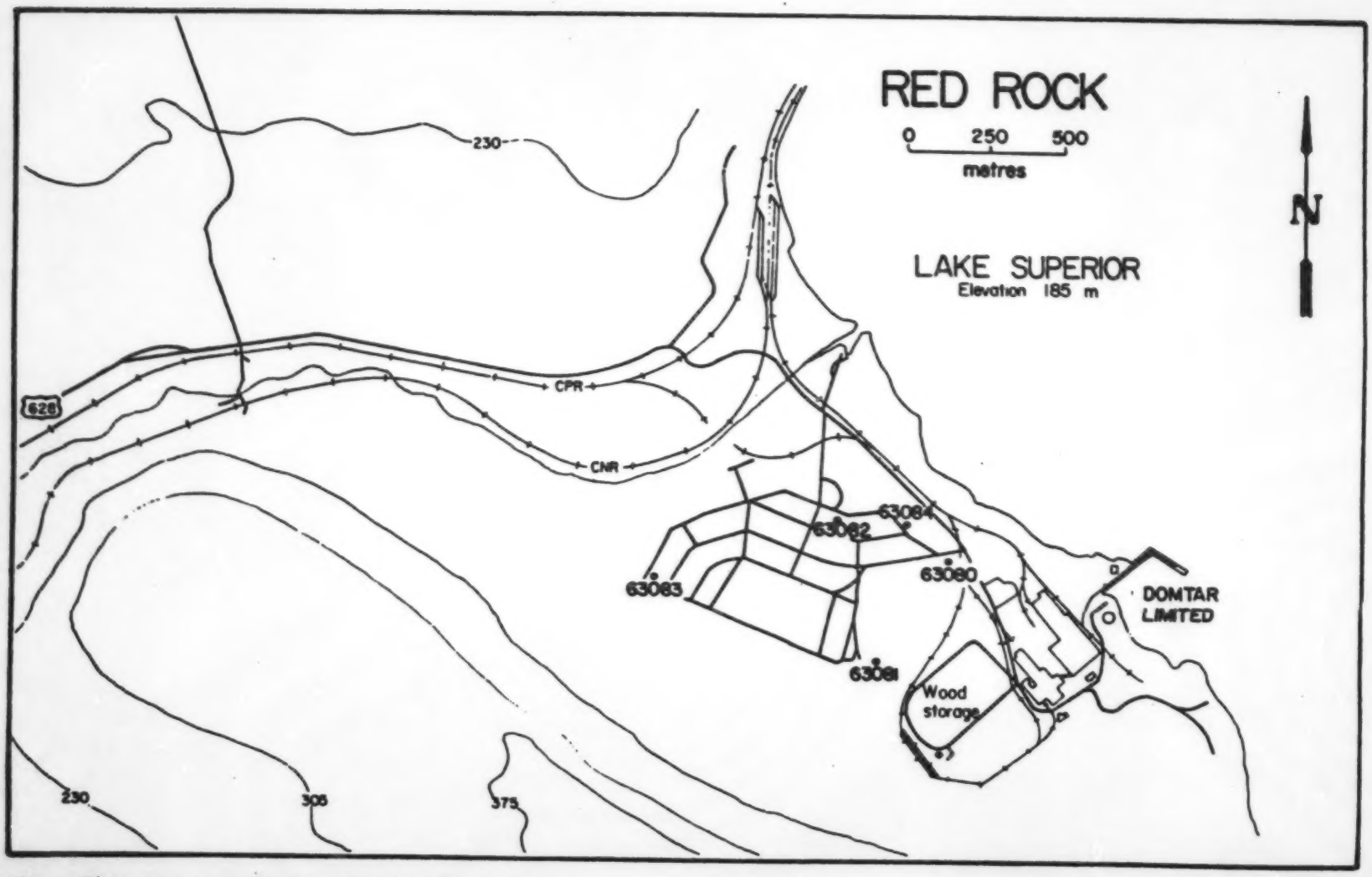

Figure 9. Air quality monitoring sites, Red Rock.

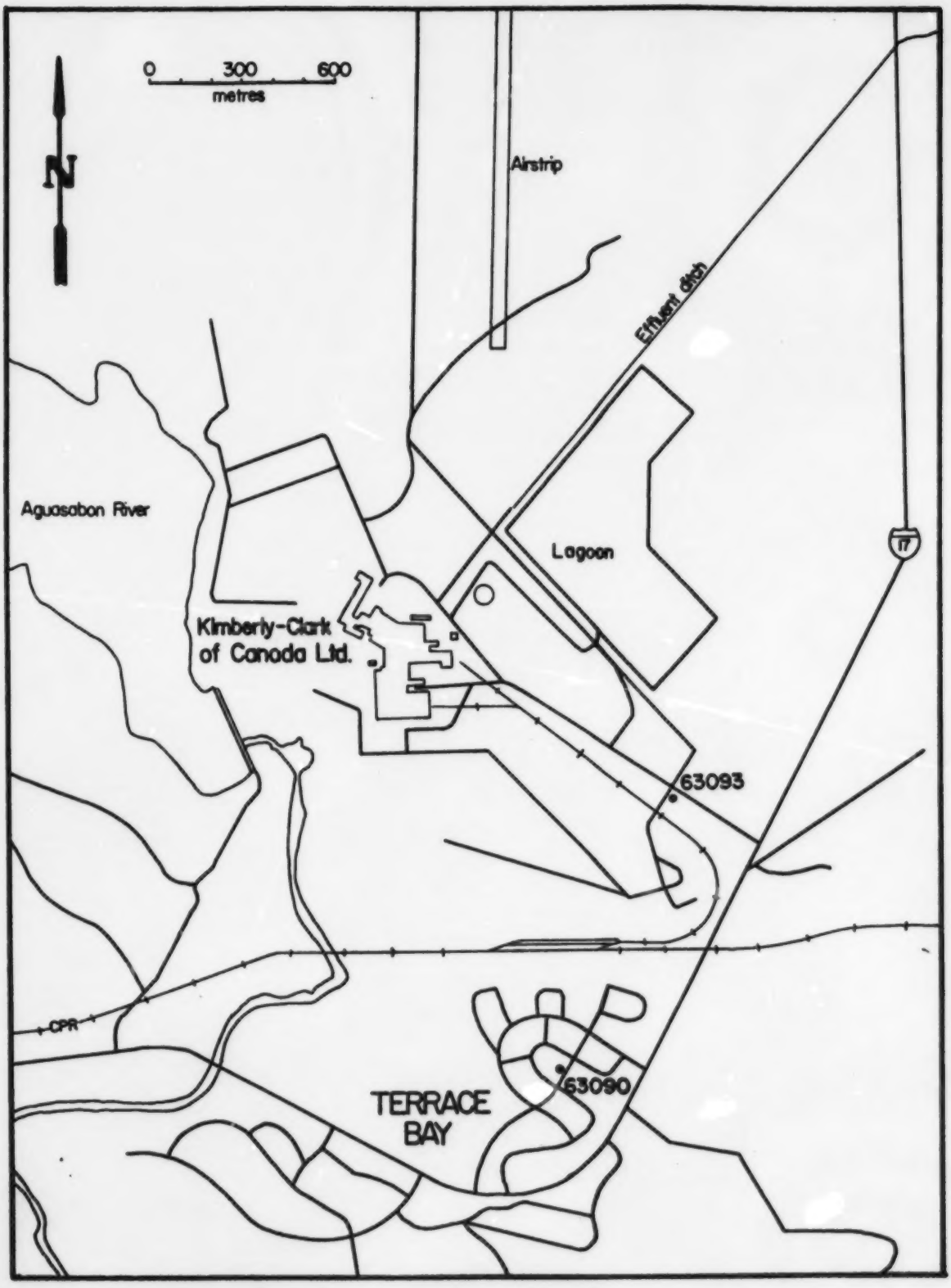

Figure 10. Location of TRS monitoring stations, Terrace Bay.

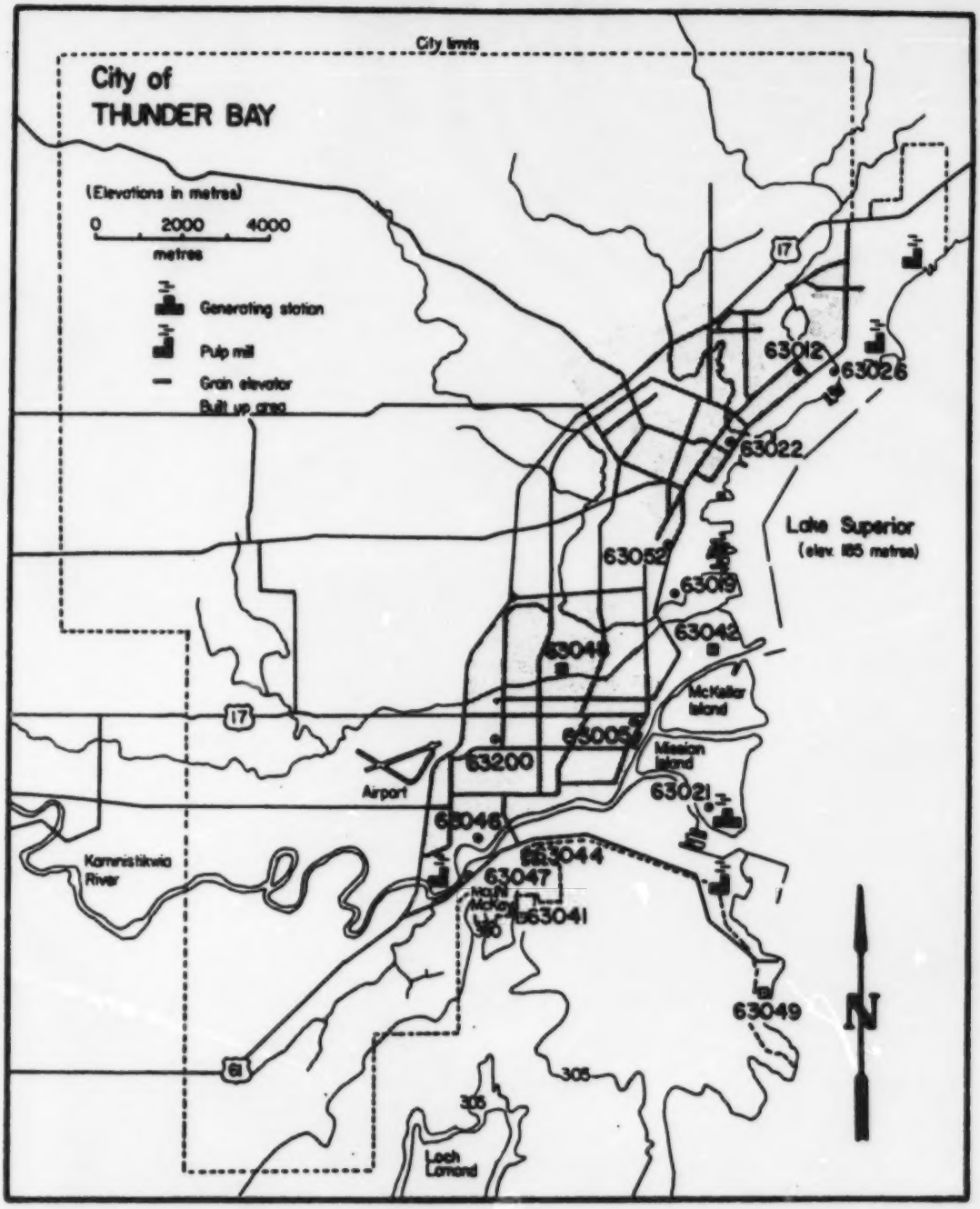

Figure II . Air quality monitoring sites, Thunder Bay.

(▣ Ontario Hydro sites)

TABLE 1. Arsenic content (μg/g, dry weight) of trembling aspen foliage, Balmertown, 1985–89.

Site[a]	1985	1986	1987	1988	1989
1	4	6	19	6	7
2	6	8	52	9	8
5	16	23	24	13	10
6	13	28	15	24	9
7	4	6	4	3	2
9[c]	6	6	7	5	4
11	13	4	11	7	9
12[c]	2	1	5	3	2
13	90	160	140	230	36
14	23	75	20	42	6
17	22	13	11	17	10
20[c]	5	2	11	7	5
21[c]	6	2	6	4	6
23	16	15	<1	7	9
24[c]	11	5	18	5	7
28	74	180	150	33	36
32	55	32	61	36	17
Controls	<1	<1	<1	<1	<1

[a] Shown in Figure 2.
[b] Values above guideline (2 μg/g) are underlined.
[c] Sites in townsite area.

TABLE 2. Average arsenic content (μg/g, dry weight) of foliage from planted roadside Manitoba maple (Acer negundo) and white elm (Ulmus americana) trees, Balmertown, 1985–89.

Site	1985	1986	1987	1988	1989
Dickenson & Mine Rd.	12	26	18	18	18
Balmertown public school	6	4	14	8	8
Fifth St. & Mine Rd.	5	12	10	7	12
Control (Red Lake)	<1	<1	<1	<1	<1

TABLE 3. Summary of sulphur dioxide data, Balmertown, 1985-89.

Year	Days of data	Annual ave. (ppm)	Annual exceedences		Growing season exceedences	
			Hours	Days	Hours	Days
1985	341	0.010	114	3	61	2
1986	355	0.008	79	2	28	1
1987	332	0.010	87	7	23	1
1988	353	0.008	53	2	19	nil
1989	334	0.010	86	3	34	2

TABLE 4. Summary of concentrations (ppb) of total reduced sulphur, Dryden, 1985-89.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1985	340	1.0	51	17
1986	352	1.0	77	12
1987	346	0.5	26	nil
1988	323	0.4	45	1
1989	362	0.4	20	nil

TABLE 5. Average chloride and sodium concentrations in unwashed Manitoba maple foliage, Fort Frances-International Falls, 1981, 1985, and 1989.

	Chloride(%, dry weight)			Sodium(μg/g, dry weight)		
Site[a]	1981	1985	1989	1981	1985	1989
1[b]	0.62	0.21	0.12	2090	680	250
2[b]	0.43	0.18	0.12	2200	690	180
3[b]	0.40	0.15	0.14	710	560	110
4[b]	0.22	0.13	0.14	330	570	170
5	0.22	0.14	0.10	330	180	120
6	0.38	0.18	0.17	800	580	250
9	0.18	0.12	0.09	130	130	110
13	0.04	0.04	0.01	72	140	60
14[c]	0.08	0.12	0.05	126	47	130
16[c]	0.16	0.14	0.15	69	110	130
18	0.11	0.08	0.07	60	310	130
20	0.09	0.08	0.06	140	420	90
21	0.11	0.16	0.14	70	120	90
22	0.12	0.14	0.04	100	490	95
23	0.12	0.09	0.08	100	200	95
24	0.24	0.25	0.09	150	79	210
25	0.20	0.26	0.14	230	130	120
28		0.13	0.16		91	230
Controls	0.08	0.06	0.05	56	27	68

[a] See Figure 6 for site locations.

[b] Sites on company property.

[c] U.S. sites.

[d] Values above contaminant guideline (350 μg/g) for sodium in vegetation are underlined.

TABLE 6. Average annual dustfall ($g/m^2/30$ d), Fort Frances, 1989.

Monitoring sites[a]	Total dustfall	Insoluble dustfall
62032	2.1	1.2
62033[b]	8.3[c]	4.3
62034	4.0	2.5
62035	7.2	4.8
62036	8.4	5.3
62037	2.2	1.0
62046[b]	15.7	11.9
62050	6.9	3.5
Average, sites off mill property	5.1	3.0
% of total dustfall, off-property sites		59

[a] See Figure 6.
[b] Sites on company property.
[c] Values above the maximum acceptable limit (4.6 $g/m^2/30$ d) are underlined.

TABLE 7. Average annual dustfall ($g/m^2/30$ d) at six Fort Frances monitoring sites off mill property, 1985–89.[a] Percentages of total dustfall are shown in parentheses.

Parameter	1985	1986	1987	1988	1989
Total dustfall	8.3[b]	7.1	5.9	6.1	5.1
Insoluble dustfall	4.9(59)	3.8(54)	3.1(52)	3.6(59)	3.0(59)
Saltcake in dustfall	0.8(10)	1.4(20)	1.1(19)	0.9(15)	NA[c]

[a] Stations 62030/35, 62032, 62034, 62036, 62037, and 62050.
[b] Insufficient data for station 62050.
[c] Not available for 1989.

TABLE 8. Summary of total reduced sulphur concentrations (ppb) at stations 62030, 62052 and 62032, Fort Frances, 1976-1989.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
	Station 62030/62052			
1976[a]	309	12.8	458	916
1977[a]	294	15.4	480	969
1978[a]	304	16.1	540	1035
1979[a]	344	10.2	353	911
1980[a]	352	9.3	499	872
1981[a]	277	12.0	279	806
1982[a]	320	8.8	543	685
1983[b]	336	4.9	254	418
1984[b]	332	2.8	98	135
1985[b]	363	2.0	191	87
1986[a,b]	335	3.9	226	300
1987[a]	359	5.5	278	431
1988[a,b]	359	5.9	268	552
1989[a,b]	365	5.0	126	414
	Station 62032			
1976	139	2.5	116	91
1977	225	3.3	129	176
1978	281	2.5	134	141
1979	306	2.9	140	178
1980	307	3.3	124	210
1981	271	3.1	211	202
1982	269	2.1	99	115
1983	309	2.8	87	180
1984	314	1.9	74	38
1985	363	1.1	61	28
1986	325	1.2	133	37
1987	345	1.8	215	61
1988	363	1.7	160	84
1989	331	1.4	262	61

[a] Station 62030
[b] Station 62052

TABLE 9. Average annual dustfall ($g/m^2/30$ d), Kenora 1985–89.

Station[a]	Location	1985	1986	1987	1988	1989
61003	Fourth/Main	5.4	3.3	3.2	4.3	3.2
61007	Melick/Ninth	9.7	8.9	7.5	9.5	5.5
61008	Melick/Eleventh	5.6	3.1	3.0	5.9	3.5
61009	Third/Matheson	5.1	3.2	3.7	4.3	3.9
	Averages	6.4	4.6	4.3	6.0	4.0

[a] See Figure 7.

[b] Values exceeding maximum acceptable level of 4.6 are underlined.

TABLE 10. Summary of TRS concentrations (ppb) at station 63034, Marathon, 1985-89.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1985	343	1.3	83	52
1986	316	2.1	131	115
1987	331	2.0	150	93
1988	327	2.2	67	109
1989	365	1.5	175	54

TABLE 11. Average annual dustfall ($g/m^2/30$ d), Red Rock, 1985-89.

Station[a]	Location	1985	1986	1987	1988	1989
63080[b]	Rankin Street	6.8	5.9	6.2	5.3	3.9
63081	Stewart/Frost	4.5	4.4	4.8	4.7	4.7
63082	47 Timmins Street	4.9	4.6	5.2	5.9	3.4
63083	122 Brompton Road	3.0	2.6	2.8	2.9	3.0
	Averages	4.8	4.4	4.8	4.7	3.8

[a] See Figure 9.
[b] Site on company property.
[c] Values exceeding maximum acceptable limit of 4.6 are underlined.

TABLE 12. Summary of TRS concentrations (ppb) at station 63084, Red Rock, 1985-89.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
1985	362	2.0	104	117
1986	317	1.9	80	87
1987	337	3.1	216	203
1988	350	2.8	201	173
1989	296	1.4	77	44

TABLE 13. Summary of TRS concentrations (ppb) at stations 63090 and 63093, Terrace Bay, 1985–89.

Year	Days of data	Annual average	Maximum 1-hour average	Number of hours above guideline
		Station 63090		
1985	364	1.4	200	67
1986	350	1.5	155	72
1987	316	2.4	159	121
1988	332	2.2	129	111
1989	342	1.4	95	64
		Station 63093		
1989	344	4.4	180	373

TABLE 14. Total dustfall ($g/m^2/30$ d), Thunder Bay, 1989.

Station[a]	Location	Monthly Min	Monthly Max	Annual average
63005	McKellar Hospital	<0.5	4.4	2.0
63012	Dawson Court	0.5	3.3	1.8
63019	Main St. Pumping Station	0.8	4.6	2.4
63021	Mission Island	0.5	3.2	1.4
63022	St. Joseph's Hospital	0.8	8.5	2.9
63026	N. Cumberland Hydro	0.7	3.5	1.6
63046	Montreal Street	1.4	5.4	2.6
63047	Totem Trailer Court	2.5	8.3	4.8
63052	Thunder Bay Transit	0.7	11.7	3.1
63200	615 James St. South	<0.5	2.4	1.3

[a] See Figure 11.
[b] Values exceeding maximum acceptable levels of 7.0 (monthly) or 4.6 (annual average) are underlined.

TABLE 15. Total suspended particulate matter ($\mu g/m^3$), Thunder Bay, 1989.

Station[a]	Number of samples	Annual geometric mean	Number of samples above 120 $\mu g/m^3$	Maximum 24-hour value
63005	58	36	nil	119
63012	58	28	1	176[b]
63022	57	36	nil	109
63046	54	52	3	220
63052	58	45	5	153
63200	56	38	nil	108

[a] See Figure 11.
[b] Values exceeding the maximum acceptable limit of 120 $\mu g/m^3$ (24-hour average) or 60 $\mu g/m^3$ (annual geometric mean) are underlined.

TABLE 16. Summary of carbon monoxide, nitrogen dioxide and ozone concentrations (ppm), station 63200, Thunder Bay, and ozone at Hawkeye Lake, 1989.

	Maximum 1-hour average	Maximum 8-hour average	Maximum 24-hour average
Carbon monoxide	6.0	3.5	
Nitrogen dioxide	0.06		0.03
Ozone, Thunder Bay	0.088		
Ozone, Hawkeye Lake[a]	0.090		

[a] 40 km north-northwest of Thunder Bay

TABLE 17. Summary of sulphur dioxide concentrations (ppm) in Thunder Bay, 1989.

Station[a]	Location	Annual average	Maximum 1-hour average	Maximum 24-hour average
63022	St. Joseph's Hospital	<0.001	0.02	<0.01
63200	615 S. James Street	<0.001	0.03	0.01
63041[b]	Mt. McKay		0.16	0.01
63042[b]	East End		0.02	<0.01
63044[b]	James St./Kam River		0.08	<0.01
63048[b]	Ford Street		0.09	<0.01
63049[b]	Chippewa Park		0.06	<0.01

[a] See Figure 11 for station locations.
[b] Ontario Hydro. 1989-90. Environmental Quality Compliance Reports, 1989. Central Production Services Division.

TABLE 18. Summary of total reduced sulphur concentrations (ppb), station 63046[a], Thunder Bay, 1985-1989.

Year	Days of data	Annual average	Maximum 1-hour average	Number of times above guideline
1985	286	0.8	27	nil
1986	337	1.0	55	4
1987	329	0.8	52	12
1988	361	1.0	36	5
1989	343	1.0	51	2

[a] See Figure 11 for station location.